

SECTION 13085

SEISMIC PROTECTION

LANL MASTER CONSTRUCTION SPECIFICATION

When editing to suit project, author shall add job-specific requirements and delete only those portions that in no way apply to the activity (e.g., a component that does not apply). To seek a variance from applicable requirements, contact the LEM Structural POC.

When assembling a specification package, include applicable specifications from all Divisions, especially Division 1, General Requirements.

Delete information within “stars” during editing.

Specification developed for ML-3 projects. For ML-1 / ML-2, additional requirements and QA reviews are required.

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Seismic protection measures for mechanical/electrical equipment and systems.

1.2 SYSTEM DESCRIPTION

- A. General

- 1. The requirements for seismic protection measures to be applied to mechanical/electrical equipment and systems specified herein are in addition to any other items called for in other Sections of these Specifications.

- B. Mechanical/Electrical Equipment

- 1. Include the following mechanical/electrical equipment to the extent required on plans or in other sections of these specifications:

Water Heaters	Steam, Water, and Gas Piping
Expansion Tanks	Drain, Waste, and Vent Piping
Heat Exchangers	Elevators
Water Chiller Units	Distribution Bus Ducts
Cooling Towers	Air and Refrigerant Compressor
Control Panels	Air Handling Units

Pumps with Motors	Panel Boards
Light Fixtures	Circuit Disconnect Devices
Motor Control Centers	Transformers
Switchboards	Storage Racks
Suspended Ceiling Assemblies	Ducts
Combination Starters	

C. Mechanical Systems

1. Include the following mechanical systems to the extent required on Drawings or in other Sections of these Specifications:
 - a. Gas Distribution
 - b. Water Supply Systems
 - c. Sanitary Sewer Systems
 - d. Process Piping

D. Zone

1. This facility is located in Seismic Zone 2B.

E. Exclusion

1. Install seismic protection of water pipes for fire protection systems per NFPA 13, Installation of Sprinkler Systems, and Appendix A.

1.3 SUBMITTALS

A. Submit the following in accordance with Section 01330, Submittal Procedures:

1. Design calculations for bridge cranes and monorails with the shop drawings.
2. Shop Drawings along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed below. Furnish shop drawings complete in detail; indicate thickness, type, grade, class of metal, and dimensions; and show construction details, reinforcement, anchorage, and installation with relation to the building construction.
 - a. Sway Braces

- b. Flexible Couplings or Joints
 - c. Resilient Type Vibration Devices
 - d. Fume Hood Discharge Stacks
3. Certification of cranes per paragraph 3.12.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Bolts and Nuts

1. Squarehead bolts and heavy hexagon nuts, ANSI B18.2.1, Square and Hex Bolts and Screws Inch Series; B18.2.2, Square and Hex Nuts; and ASTM A 307, Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
2. Bolts, underground, ASTM A 325, High Strength Bolts for Structural Steel Joints.

B. Sway Brace

1. Structure Steel: Conform to ASTM A36, Structural Steel.
2. Steel Pipe: Conform to ASTM A501, Hot Formed Welding and Seamless Carbon Steel Structural Tubing.
3. Steel Bars: Conform to ASTM A576, Steel Bars, Carbon, Hot-Wrought, Special Quality.

C. Flexible Couplings

1. Provide flexible couplings with the same pressure ratings as adjoining pipe.
2. Flexible ball joints conforming to the following requirements may be employed on above ground piping. Provide joints that have cast or wrought steel casing and ball parts capable of 360 degree rotation plus not less than 15 degree angular movement.
3. Flexible couplings and joints of the mechanical joint type may be used for aboveground or underground piping.
 - a. Use sleeve type mechanical couplings for steel or cast-iron pipe that provide a tight flexible joint under all reasonable conditions, such as pipe movement caused by expansion, contraction, slight settling or shifting of the round, minor variations in trench gradients, and traffic vibrations. Where permitted in other sections of these specifications, joints utilizing split-half couplings with grooved or shouldered pipe ends may be used.

- b. Use sleeve-type couplings for joining plain-end pipe sections. Provide couplings consisting of one steel middle ring, two steel followers, two gaskets, and necessary steel bolts and nuts to compress the gaskets. Use high-strength underground bolts type as specified above.

D. Guy Wires

- 1. Guy wire: Conform to Fed. Spec. RR-W-410, Wire Rope and Strand, as follows:

5/32 inch diameter	Type V, Class 1
3/16 inch to 5/16 diameter	Type V, Class 2
1/4 inch to 5/8 diameter	Type I, Class 2

E. Lighting Fixture Supports

- 1. Fixture supports: Malleable iron.

PART 3 EXECUTION

3.1 SWAY BRACES

- A. Install sway braces on piping and duct to preclude damage during seismic activity. Provide bracing to the arrangements shown. Provision of this paragraph applies to piping within a 5 foot line around outside of building unless buried in the ground. Brace piping grouped for support on trapeze-type hangers at the same intervals as determined by the smallest diameter pipe of the group.
- B. Secure trapeze-type hanger with not less than two 1/2 inch bolts. Do not use bracing rigidly attached to pipe flanges, or similar, where it would interfere with thermal expansion of piping.
- C. Sway Braces for Piping
 - 1. Transverse Sway Bracing
 - a. Provide transverse sway bracing at intervals not to exceed those given in Schedule "Maximum Space for Transverse Sway Braces in Seismic Zone 4," except for cast-iron soil pipe. Brace cast-iron soil pipe at not more than 10 foot intervals.
 - 2. Longitudinal Sway Bracing
 - a. Provide longitudinal sway bracing at 40 foot intervals.
 - 3. Vertical Runs
 - a. Brace vertical runs of piping at not more than 10 foot vertical intervals. For smaller tubing, provide bracing at no more than 4 foot spacing.

4. Anchor Rods, Angles, and Bars

- a. Bolt anchor rods, angles, and bars to either pipe clamps or pipe flanges at one end and cast-in-place concrete or masonry insert or clip angles bolted to the steel structure on the other end. Use solid metal rods or pipe as specified below. Do not exceed lengths given in Schedule "Maximum Length for Anchor Braces."

5. Clamps

- a. Apply clamps on uninsulated pipes directly to pipe. Apply clamps to insulated piping over insulation vapor barrier with high-density inserts and metal protection shields under each clamp.

6. Bolts

- a. Use 1/2 inch minimum diameter bolts for attachment of anchors to pipe and structure.

D. Sway Braces for Ducts

1. Transverse Sway Bracing

- a. Provide transverse sway bracing at each horizontal turn of 45 degrees or more, at the end of each duct run, and otherwise at each 30 foot interval. Walls which ducts penetrate may be considered transverse braces.

2. Longitudinal Sway Bracing

- a. Provide longitudinal sway bracing at 60 foot intervals. Transverse bracing for one duct sections may also act as longitudinal bracing for a duct section connected perpendicular to it, if the bracing is installed within 4 feet of the intersection, and it is sized for the larger duct.

3. Bracing Angles

- a. Provide bracing angles for rectangular ducts in accordance with Schedule "Bracing for Rectangular Ducts."

3.2 SPREADERS

- A. Provide spreaders between racked or adjacent piping runs to prevent contact during seismic activity whenever pipe or insulated pipe surfaces are less than 4 inches apart or four times the maximum displacement due to seismic force. Apply spreaders at same interval as way braces and to surface of bare or insulated hot pipe and over insulation utilizing high-density inserts and pipe protection shields where vapor-barrier-type insulation is employed.

3.3 FLEXIBLE COUPLINGS OR JOINTS

A. Building Piping

1. Provide flexible couplings or joints in building piping at bottom of pipe risers larger than 3 inches in diameter. Cast-iron waste and vent piping need only comply with these provisions when caulked joints are used. Flexible bell and spigot pipe joints using rubber gaskets or non-hub fittings may be used at each branch adjacent to tees and elbows for underground waste piping inside of building to comply with these requirements.

3.4 UNDERGROUND PIPING

A. Install flexible couplings adjacent to buildings in underground piping and 4 inch or larger conduit, except heat distribution system. Provide additional flexible couplings as follows:

1. On each side of the joints of demarcation between soils having widely differing degrees of consolidation.
2. At points that can be considered to act as anchors.
3. On every branch of a tee and each side of an elbow.

3.5 EMERGENCY GAS SUPPLY CONNECTIONS

- #### A. Provide facilities which are to be connected to natural gas distribution systems with an aboveground locked, valved and capped emergency gas supply connection. Provide for attachment of a portable, commercial-sized gas cylinder system to this connection. Locate connection within 12 inches of the exterior wall, clearly marked with an appropriate metal sign mounted on wall above. Provide an automatic device to safely interrupt the flow of gas to the building in case of an earthquake as shown.

3.6 ANCHOR BOLTS

- #### A. Use cast-in-place anchor bolts on floor or pad mounted equipment required by any Section of these Specifications. Provide anchor bolts conforming to the schedule for the various equipment weights or the manufacturer's installation recommendations, whichever is the most stringent. Extend anchor bolts that exceed normal depth of equipment foundation piers into the concrete floor or the foundation as necessary to accommodate bolt lengths. Do not use expansion anchors to resist seismic or vibratory loads unless test data are provided to verify the adequacy of the specific anchor and application. The expansion anchor size is never to be less than that required for bolts in the schedule.

3.7 RESILIENT VIBRATION ISOLATION DEVICES

- #### A. Follow the same procedure as in paragraph entitled "ANCHOR BOLTS" for selection of anchor bolts for vibration isolation devices and/or snubbers to equipment base and foundations, except use an equipment weight equal to five time the actual equipment weight.

B. Resilient and Spring-Type Vibration Devices

1. Select vibration isolation devices so that the maximum movement of equipment from the static deflection point is 0.5 inches.

C. Multidirectional Seismic Snubbers

1. Refer to Section [15070], Mechanical Sound and Vibration Control.

3.8 EQUIPMENT SWAY BRACING

A. Sway Bracing: Conform to Schedule, Maximum Length for Anchor Bracing.

- B. Provide equipment sway bracing for items supported from overhead floor or roof structures. Provide braces consisting of angles, rods, bars, or pipes arranged as shown and secured at both ends with not less than 1/2 inch bolts. Provide bracing in 2 planes for directions, 90 degrees apart, for each item of equipment. Provide sufficient braces for equipment to resist a horizontal force equal to 56 percent of the weight of equipment without exceeding safe working stress of bracing components. Submit details of equipment bracing for approval. Instead of bracing with vertical supports, these items may be supported with hangers inclined at 45 degrees directed up and radially away from equipment and oriented symmetrically in 90 degree intervals on the horizontal plan, bisecting the angles of each corner of the equipment, provided that supporting members are properly sized to support operating weight of equipment when hangers are inclined at a 45 degree angle.

3.9 LIGHTING FIXTURES IN BUILDINGS

A. Pendant Fixtures

1. Provide loop and hook or swivel hanger assemblies for pendant fixtures with a restraining device to hold the stem in the support position during earthquake motions. Also provide pendant-supported fluorescent fixtures with a flexible hanger device at the attachment to the fixture channel to preclude breaking of the support. Ensure the motion of swivels or hinged joints does not cause sharp bends in conductors or damage to insulation.

B. Recessed Fluorescent Fixtures

1. Support recessed fluorescent individual or continuous-row fixtures by a seismic-resistant suspended ceiling support system and bolt at each corner of the fixture; or provide with fixture support wires attached to the building structural members using 2 wires for individual fixtures and 1 wire per unit of continuous row fixtures.

C. Assembly Mounted on Outlet Box

1. Design a supporting assembly that is intended to be mounted on an outlet box to accommodate mounting features on 4 inch boxes, 3 inch plaster rings, and fixture studs.

D. Surfaces-Mounted Fluorescent Fixtures

1. Attach surface-mounted fluorescent individual or continuous-row fixtures to a seismic-resistant ceiling support system. Provide locking type scissor clamp or a full loop bank fixture support devices for attaching to suspended ceilings that securely attaches to the ceiling support. Properly anchor fixtures attached to underside of a structural slab to the slab at each corner of the fixture.

E. Wall-Mounted Emergency Light Unit

1. Secure each wall-mounted emergency light unit in a manner to hold the unit in place during a seismic disturbance.

F. Tests

1. In lieu of the requirements for equipment supports, lighting fixtures and the complete fixture-supporting assembly may be tested as specified hereinafter. Conduct such a test by an approved and independent testing laboratory, and the test results will specifically indicate whether or not the lighting fixture support satisfies the requirements given herein.

2. Test Equipment

- a. To simulate earthquake motion, attach fixtures and supports to a carriage suspended on rollers from an overhead track. Use a gear motor and crank assembly to provide oscillatory motion of approximately one cycle per second. Adjust the exact number of cycles per second and the actual dimensions of the crank apparatus to produce a minimum carriage acceleration that is appropriate for the Performance Category of the facility. The location of the actual fixture-mounting surface is on the underside of the carriage. The surface provides capacity for orienting the fixture in a horizontal plane in positions ranging from parallel to perpendicular to the line of traverse.

3. Test Requirements

- a. Conduct test with the maximum fixture weight to produce the most severe loading conditions. Test fixtures having stems with the actual stem lengths to be used. Conduct the test for a duration of one minute, with the mounting surface in the line of traverse, at 45 degrees to the line of traverse, and at 90 degrees to the line of traverse. Test a total of two fixtures in each of the above positions. After each of the 6 tests, subject the complete stem assemblies from fixtures having stem assemblies to a tensile strength test. Ensure that the sample can withstand, without failure, a force of not less than 4 times the weight it is intended to support.

4. Acceptance

- a. Individual components of a fixture or its supports are unacceptable. An acceptable fixture and its supports should be undamaged, and any component of the fixture should not fail or fall from the fixture during testing.

G. Design Criteria

1. In lieu of the above test requirements, design lighting fixtures to resist a lateral force of 56 percent of the fixture weight.

3.10 SUSPENDED ACOUSTICAL CEILING ASSEMBLIES

- A. The structural members of ceiling systems used primarily to support acoustical tile panels or acoustical panel lay-in tiles, with or without lighting fixtures, ceiling-mounted air terminals, and ceiling-mounted services, shall conform to the following:

B. Design Criteria

1. Design the main runners and cross-runners and their splices and intersection connections for two times the design load or ultimate axial tension or compression (minimum 120 pounds). Provide mechanical interlocking type connections at the splices and intersections. Design ceiling structural systems to withstand required vertical load as well as a lateral force of 11.3 percent of the ceiling weight. Include in the ceiling weight lighting fixtures and other equipment that are laterally supported by the ceiling and with a minimum of 4.0 psf. Exception: Ceiling area of 144 square foot or less surrounded by walls that connect directly to the structure above is exempt from the lateral-load standards of this specification.

C. Minimum Installation Requirements

1. Minimum installation requirements, in accordance with ASTM E 580, Application of Suspension Systems for Acoustical Tile and Lay-In Panels in Areas Requiring Seismic Restraints, are as follows:
 - a. Vertical Support: Ensure hanger wires supporting a maximum tributary ceiling area of 16 square feet are a minimum of 10 gage in diameter. Ensure the size of wire supporting a tributary ceiling area greater than 16 square feet is substantiated by design calculations. Ensure hanger attachment devices used in ceiling systems do not exceed 4 psf and are capable of supporting a minimum allowable load of 100 pounds. Ensure hanger attachment devices used in ceiling systems exceeding 4 psf are capable of supporting the design load and are substantiated by design calculations. Install hangers that are plumb and that do not attach to or bend around interfering duct pipes or similar obstructions. If hangers must be splayed more than one horizontal to six vertical, offset the resulting horizontal force by bracing, counter-splaying, or other acceptable means and substantiate by design calculations. Independently support the terminal end of each cross runner or main runner within 8 inches of a wall.

- b. Lateral Support: In lieu of the design criteria stated above, where ceiling loads do not exceed 4 psf, lateral support for the ceiling system may be provided by four wires of minimum No. 10 gage, splayed in four directions, 90 degrees apart, and connected to the main runner with 2 inches of the cross runner and to the structure above at an angle not exceeding 45 degrees from the plane of the ceiling. Place these lateral support points 12 feet on center in each direction with the first point within 4 feet from each wall. Make allowances for lateral movement of the system. Main runners and cross runners may be attached at two adjacent walls with clearance between the walls and the runners maintained at the other two walls.

D. Lighting Fixture and Air Diffuser Supports

- 1. Design and install lighting fixture and air diffuser supports to meet the requirements of equipment supports in the proceeding paragraphs of this specification with the following exceptions:
 - a. Recessed lighting fixtures not over 56 pounds in weight and suspended and pendant-hung fixtures not over 20 pounds in weight may be supported and attached directly to the ceiling system runners by a positive attachment such as screws or bolts.
 - b. Air diffusers that weigh not more than 20 pounds and that receive no tributary loading from ductwork may be positively attached to and supported by the ceiling runners.

3.11 FUME HOOD DISCHARGE STACKS

- A. Construct stacks up to 50 feet total height of steel plates listed in Schedule "Smoke Stacks and Guy Wires."
- B. Support stacks with steel guys attached at a point three-fourths of the stack height external to the building, unless otherwise indicated.
- C. Structurally check stacks taller than 50 feet and detail on drawings. Support stacks passing through buildings in chases to the roof by fire-resistant construction at not more than 20 foot intervals and the wall thickness need not be increased for building height.

3.12 CRANES

- A. Design cranes to accommodate the following horizontal equivalent static force of 0.23 times weight, applied in any direction to the center of gravity of the equipment. The weight of such equipment should not include any live load, and the equivalent static force so computed will be assumed to act nonconcurrently with other prescribed nonseismic horizontal forces when considering the design of the crane and monorails. Provide a suitable crane design for the forces previously specified in addition to the normal horizontal loads prescribed by standards cited in other sections of these specifications. Submit to LANL a proper certification that the crane system has been checked for seismic forces as specified herein and found satisfactory.

3.13 RAISED FLOOR SYSTEMS

- A. Construct and assemble raised floor systems with the capability of withstanding a horizontal equivalent static force of 0.17 times a weight equivalent to the dead load of the flooring system, plus 75 pounds per square foot to account for the dead load of equipment. Anchor the raised floor pedestals with mechanical fasteners capable of withstanding the overturning moment and shear induced by the horizontal equivalent static force applied in any direction to the top of the pedestal. Ensure that the floor system is a moment resisting system providing maximum accessibility.

3.14 MISCELLANEOUS EQUIPMENT

- A. Construct and assemble the following specific items of equipment to be furnished under this contract with the capability of withstanding the horizontal equivalent static force percentage, that is appropriate for the Performance Category of the facility, times the operating weight of the equipment, at vertical center of gravity of the equipment without causing permanent deformation, dislocations, separation of components, or other damage, which would render the equipment inoperative for significant periods of time following an earthquake.

Miscellaneous Equipment

Chillers

Air-Handling Units

Cooling Towers

Transformers

Switchboards

Motor Control Centers

Panel Boards

Free Standing Electric Motors

3.15 SCHEDULES

- A. Bracing for Rectangular Ducts

1. Angle and bolt sizes apply to all seismic zones.

Duct Size*	Vertical and Long'l Angles	Diagonal Angles	Horizontal Angles	Bolt Size
30" sq	2x2x16 gage	2x2x16 gage	2x2x16 gage	1/4"
42" sq.	2-1/2x2-1/2x16 gage	2-1/2x2-1/2x16 gage	2-1/2x2-1/2x16 gage	1/4"
54" sq.	2-1/2x2-1/2x16 gage	2-1/2x2-1/2x14 gage	2-1/2x2-1/2x16 gage	3/8"
60" sq.	3x3x16 gage	3x3x14 gage	3x3x16 gage	3/8"
*The ducts maximum dimension governs what bracing is required. Example: Brace a 36" x 60" duct as a 60 inch square duct.				

B. Maximum Span for Transverse Sway Braces in Seismic Zone 4.

Pipe Diameter (in.)	Std. Wgt. Steel Pipe - 40S		Ex. Strong Steel Pipe - 80S		Copper Tube Type L	
	*L (ft)	**F (lbs)	*L (ft)	**F (lbs)	*L (ft)	**F (lbs)
1	22	70	22	80	11	17
1-1/2	25	140	26	180	12	35
2	29	220	30	290	14	70
2-1/2	32	380	33	460	15	100
3	34	550	35	710	17	150
3-1/2	36	730	38	930	18	220
4	39	960	40	1,200	19	300
5	41	1,440	44	1,900	20	470
6	45	2,120	46	2,750	22	730
8	49	3,740	54	5,150	26	1,500
10	54	6,080	59	7,670	28	2,630
12	58	8,560	61	10,350	31	3,950

*L = Maximum span between lateral supports multiplied by 1.1 for Zone 3, 1.25 for Zone 2, or 1.35 for Zone 1.
 **F = Horizontal force on the brace multiplied by 0.8 for Zone 3, 0.5 for Zone 2, and 0.3 for Zone 1.
Note: Provide bracing consisting of at least one vertical angle 2 x 2 x 16 gage and one diagonal angle of the same size.

C. Maximum Length for Anchor Braces

Type	Size (inches)	Maximum Length*	Allowable Loads* (kips)
Angles	1 1/2 x 1 1/2 x 1/4	4'-10"	5.7
	2 x 2 x 1/4	6'-6"	7.8
	2 1/2 x 1 1/2 x 1/4	8'-0"	9.8
	3 x 2 1/2 x 1/4	8'-10"	10.8
	3 x 3 x 1/4	9'-10"	11.9
Rods	3/4	3'-1"	3.7
	7/8	3'-8"	5.0
Flat Bars	1 1/2 x 1/4	1'-2"	3.1
	2 x 1/4	1'-2"	4.1
	2 x 3/8	1'-9"	6.2
Pipes (40S)	1	7'-0"	4.1
	1 1/4	9'-0"	5.5
	1 1/2	10'-4"	6.6
	2	13'-1"	8.9

*Based on the slenderness ratio of $l/r = 200$ and ASTM A 36 steel.

D. Minimum Bolt Sizes, Cast-In-Place Anchor Bolts

Maximum Equipment Weight (Pounds)	Minimum Bolt Size (Inches)*
500	1/2
1,000	1/2
5,000	1/2
10,000	1/2
20,000	1/2
30,000	1/2
50,000	1/2
100,000	3/4
* Based on 4 bolts per item, a minimum embedment of 12 bolts diameters, a minimum bolt spacing of 16 bolts diameters and a minimum edge distance of 12 bolts diameters. Use equivalent total cross-sectional area when more than 4 bolts per item are provided.	

E. Stacks and Guy Wires

- Construct stacks up to 50 feet total height of steel plates as follows:

Thickness	Maximum Diameter (inches)
16 gage	14
14 gage	16
12 gage	18
10 gage	24
3/16 inch	40
*Increase 1/16 inch corrosion allowance for stacks without corrosion control.	

- Provide either iron, annealed steel, or improved plow steel guy wires, as noted, with galvanized coating.

Stack Diameter (inches)	On Ground	Guy Wire Diameter (inches) On Building
Up to 14	5/32 (1)	1/4 (3)
Up to 16	3/16 (2)	5/16 (3)
Up to 18	1/4 (2)	3/8 (3)
Up to 24	1/4 (3)	7/16 (3)
Up to 40	5/16 (3)	5/8 (3)
(1) 1 x 7 cable, iron, or annealed steel. (2) 1 x 19 cable, iron, or annealed steel. (3) 6 x 19 cable, improved plow steel with fiber core. * These sizes are adequate for the required seismic forces, but wind must be checked separately.		

END OF SECTION